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Zooplankton Changes Along the Newfoundland - Gulf of Maine 1994 CPR Line and 1995 Halifax Line

by

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[1]La présente série documente les bases scientifiques des évaluations des ressources halieutiques sur la côte atlantique du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

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Abstract

The CPR data showed 1994 was a year of average to lower than average levels of copepods on the transect from Newfoundland to Georges Bank. The phytoplankton greenness index and the total number of fish larvae were above the long term mean. The zooplankton levels in April 1995 were very high on the Halifax Line but declined to low levels in July and were lower than normal in October. The macrozooplankton levels on the Halifax Line were low in July and October. This decline in macrozooplankton levels appeared to be related to the exceptionally warm water on the shelf in the early summer and fall. A close positive relationship between euphausiids and pelagic fish exists in Emerald Basin with both groups showing a significant decline in 1995.

Résumé

Les données de l'enregistreur à plancton en continu ont révélé que, en 1994, l'abondance des copépodes le long du transect entre Terre-Neuve et le banc Georges se situait entre moyenne à inférieure à la moyenne. L'indice de verdissage par le phytoplancton et le nombre total de larves de poisson se situaient au-dessus de la moyenne à long terme. L'abondance du zooplancton sur la ligne d'Halifax en avril 1995 était très élevée, mais a chuté en juillet, pour ensuite devenir plus faible que la normale en octobre. L'abondance du macrozooplancton sur la ligne d'Halifax était faible en juillet et en octobre. Cette baisse semble être liée à la présence d'eau exceptionnellement chaude sur la plate-forme continentale au début de l'été et en automne. Une étroite relation positive entre les euphausiacés et les poissons pélagiques existe dans le bassin d'Émeraude; l'abondance de ces deux groupes a accusé une importante baisse en 1995.

Newfoundland to Georges Bank 1994 CPR Zooplankton

The CPR data were divided into three sections, SW Grand Banks, Scotian Shelf and Georges Bank sections based on longitude (Fig. 1). The phytoplankton greenness index (a measure of the amount of chlorophyll on the silk) was significantly lower in 1994 than in 1993, but it still was above the long term mean value for the three geographic sections (Fig. 2). Total copepod numbers also showed a decline in 1994 with the numbers near the long term mean on the SW Grand Banks section but below the mean on the other two sections. All species of copepods except *Calanus glacialis* (an Arctic species) on the SW Grand Banks and *Clausocalanus* spp. on the Scotian Shelf showed declines in abundance in 1994. Total copepods on the Shelf and Georges Bank had large declines in 1994 compared to 1993 abundances. Total euphausiids had a slight increase in all three regions with the numbers close to the long term mean. The total fish larvae remained at similar levels to 1993 on the SW Grand Banks but decreased in the other two regions. However, the total fish larvae abundance was still above the long term mean in all regions.

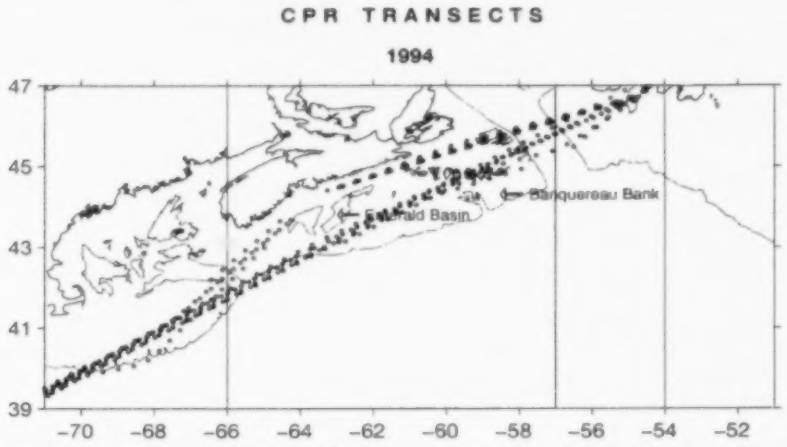

Fig. 1. Track of the CPR sampling stations in 1994 showing the three longitudinal sections SW Grand Banks, Scotian Shelf and Georges Bank.

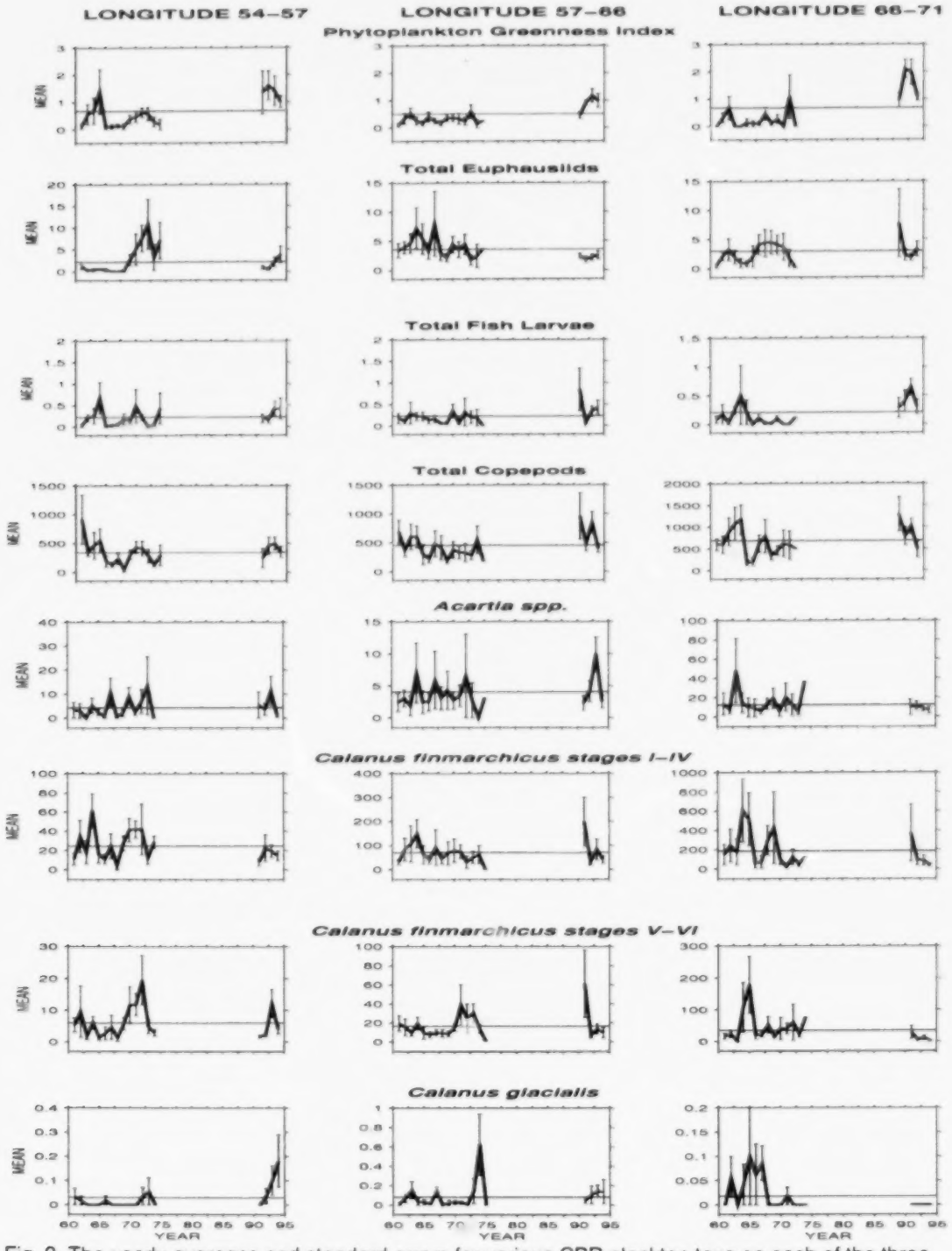

Fig. 2. The yearly averages and standard errors for various CPR plankton taxa on each of the three longitudinal sections. The horizontal line in each of the panels represents the long term mean for that taxon. There are no data between 1975 and 1990.

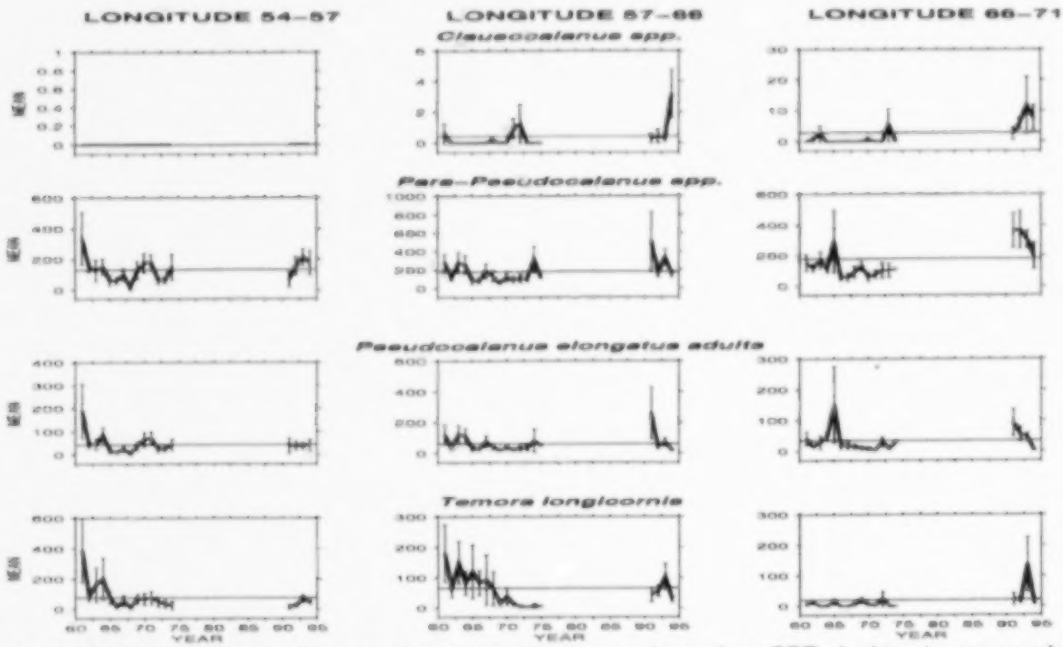

Fig. 2. (Continued) The yearly averages and standard errors for various CPR plankton taxa on each of the three longitudinal sections. The horizontal line in each of the panels represents the long term mean for that taxon. There are no data between 1975 and 1990

Halifax Line 1995

The Halifax Line was sampled during the spring, summer and fall in 1995 using conventional plankton nets, the BIONESS, the OPC/CTD and multifrequency acoustics (Sameoto et al. 1990a and 1990b, 1993, Herman et al. 1993). Seven stations were occupied on the Line (Fig. 3) with zooplankton sampled at different depth strata on each station. Acoustic backscattering data were collected at 5 frequencies (12, 50, 105, 153 and 200 kHz) along the entire transect to map the distribution and estimate the concentration of different size classes of macrozooplankton (> 1 cm), micronekton and pelagic fish. The OPC provided data on the vertical distribution of zooplankton concentrations as well as CTD information on each of the stations.

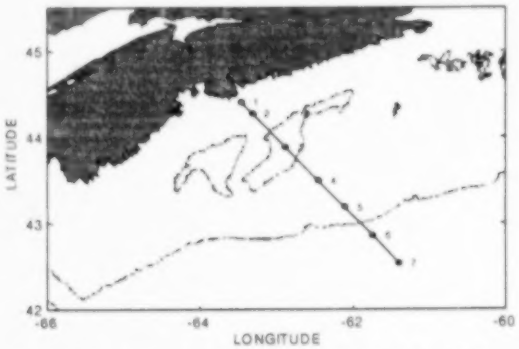

Fig. 3. Sampling stations on the Halifax Line in 1995. Dashed line represents the 200 m contour, station 3 is in Emerald Basin, 4 and 5 are on Emerald Bank.

1995 Halifax Line Temperature, Salinity and Copepod Concentrations

CTD profiles were made on each of the stations on the Halifax Line in April , July and October, 1995. Temperature and salinity profiles are shown for selected stations (Fig. 4). Temperatures of the cold intermediate layer during April 1995 were significantly warmer than in previous years, with no values < 0°C (Fig. 4). In addition, the top 75m of water was warmer than in 1994.

In July the top 10m was very warm (close to 17° C) across the entire shelf. During October the warm layer (~16°C) increased in thickness to about 50 m over the entire Halifax Line (Fig. 4).

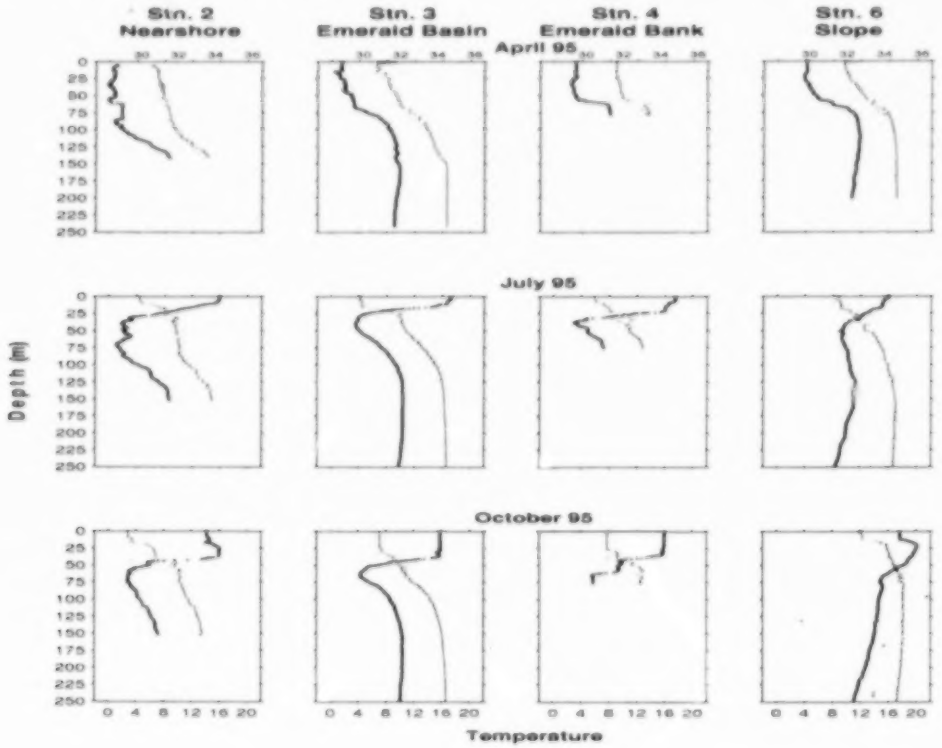

Fig. 4. Temperature (the darker solid line) and salinity profiles on selected stations on the Halifax Line during April, July and October, 1995.

Copepod concentrations in April, 1995 were amoung the highest ever recorded. This was the case across the entire Halifax Line extending on to the continental slope. In contrast, July copepod concentrations in the upper 50m of water were low on all stations except for station 4 on Emerald Bank. In October the low concentration on all stations may have been the result of the warm surface water on the shelf.

ADCP Backscattering

Acoustic backscattering levels at 153 kHz were recorded throughout the water column along the Halifax Line during April, July and October 1995 using a RDI ADCP (cochrane et al. 1994, Zhou et al. 1994, RD Instruments 1990). The recorded backscattering was primarily from macrozooplankton and micronekton

in the size range of 0.5 - 4 cm length. On the Shelf the principal acoustic scatterers at this frequency are euphausiids both juveniles and adults (Cochrane et al. 1994, 1991). Therefore these acoustic data are good indicators of changes in euphausiid abundance both across the shelf and between different months of the year. The changes in volume backscattering strength from euphausiid backscattering are roughly equivalent to changes in their biomass concentration or density, i.e. a 10 dB change in backscattering corresponds to a 10 fold change in biomass density.

Simultaneously with the recording of the RDI data, acoustic backscattering data at 12, 50, 105 and 200 kHz were also recorded using conventional echosounders. The 12 kHz frequency provided information on the relative abundance and distribution of juvenile and adult fish throughout the water column. **(In the following discussion the term 'fish' will mean any fish in the water column including ground fish.)** During the spring the dominant pelagic and larval fish on the shelf was sand lance and in the fall it was the silver hake. By comparing the levels of backscattering at 12 kHz and 200 kHz it is possible to detect relative changes in the abundance of fish and euphausiids between different locations and seasons as well as to detect year to year changes in their relative abundances.

Seasonal Changes in 153 kHz Backscattering

April 1995

High daytime levels of 153 kHz backscattering were detected in the region of Emerald Basin extending from a depth of 100m to near bottom (Fig. 5). The levels of backscattering were as high as any we have recorded in the last 10 years. In contrast to the 153 kHz values the 12 kHz levels were quite low over the Halifax Line except for a small region in the deepest region of Emerald Basin and few small patches of high scattering on Emerald Bank. These data suggested a large population of euphausiids on the shelf and a low population of pelagic fish. There was little evidence of significant numbers of pelagic fish larvae and / or juveniles.

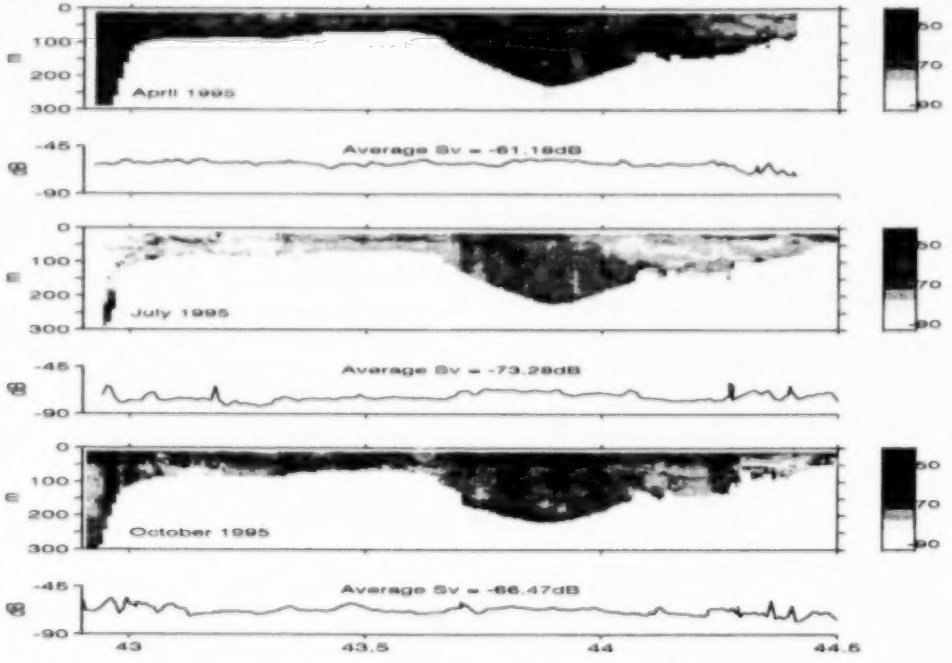

Fig. 5. ADCP volume backscattering strength (Sv) across the Halifax Line during April, July, and October 1995 showing the dB contours and color bar plus the average water column backscattering per m^3 (line drawing) and the spacially averaged dB per m^3 for the entire Line.

July 1995

In July the levels of 153 kHz backscattering on the Halifax Line were significantly reduced (by a factor of 16 times) from those seen in April (Fig. 5). This reduction was due primarily to the normal die-off of euphausiids after they reproduce in June. However,it is possible that the abnormally warm water on the shelf at this time may have also adversely affected the growth of young euphausiids. The mesozooplankton (< 1 cm) levels in this warm water layer were also extremely low.

October 1995

In October, 153 kHz backscattering levels were lower than those in November, 1992. Preliminary analysis of the BIONESS samples of euphausiids confirmed that concentrations of euphausiids were abnormally low in October.

Euphausiid and Silver Hake trends 1984-1995

Acoustic data collected over the last decade in Emerald Basin has shown a close relationship between the volume backscattering at 12 and 200 kHz (Fig. 6). The 12 kHz data reflected the concentrations of pelagic fish in the basin and the 200 kHz frequency data provided an accurate estimate of the euphausiid concentrations. The relationship between these two frequencies over the years 1985 to 1995 showed a significant positive correlation. Both frequencies showed a general increase between 1985 and 1994 followed by a significant decrease in values in 1995. These data indicated a close relationship between the fish and euphausiids in Emerald Basin. Silver hake and redfish, the two dominant pelagic species, feed primarily on euphausiids in the Basin (Waldon, 1988).

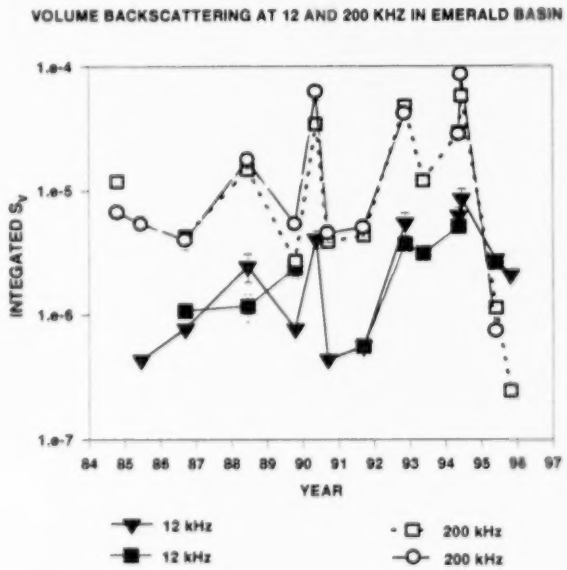

Fig. 6. Relationship between integrated volume backscattering for the pelagic fish (12 kHz) and euphausiids (200 kHz) in Emerald Basin from 1985 to 1995. Intergration depth limits were chosen to separate the fish and euphausiid populations.

Siphonophores

Siphonophores are free swimming colonies of hydroids, (that can be more than a metre long), and are usually associated with warm water. They are predators on zooplankton and fish larvae and can have a serious impact on populations of these animals if they exist in high concentrations. Siphonophores contain small gas bubbles that makes them excellent sound scatterers. We have found that the siphonphores on the Shelf scatter efficiently at 50 kHz compared to other macrozooplankton a result also suggested by the theoretical and experimental studies of Stanton et al. (1994). This property allowed us to identify these animals over a range of depths by using multifrequency acoustics. These animals were rare from 1985 to 1994 on the Scotian shelf, but were extremely abundant (~ one / m^3) in the Gulf of Maine during 1991 to 93. In October 1995 in Emerald Basin siphonphores were more abundant (1 / 10 m^3) than we have seen during the last ten years. We may be seeing a build up of their population size similar to levels seen in the Gulf of Maine in 1991, and this has the potential to depress the size of the copepod population.

Calanus finmarchicus in Emerald Basin

C. finmarchicus accumulate in Emerald Basin during the summer and fall and remain in the deep water until the breeding season in the late winter and early spring. It is believed that the size of the fall population of *C. finmarchicus* in the Basin in the fall is a good indicator of the size of the previous spring and summer's population on the Scotian Shelf (Sameoto and Herman 1990). The changes in the fall populations in the Basin between 1984 to 1995 are shown in Fig. 7. The 1995 population of *C. finmarchicus* increased slightly from the 1994 level. The temperature anomaly at 50 m in June and the numbers of *C. finmarchicus* appeared to be related, showing that as the temperature increased there was generally an increase in the size of *C. finmarchicus* population. *C. glacialis* and C. *hyperboreus* (both Arctic species) had low concentrations in the Basin in 1995.

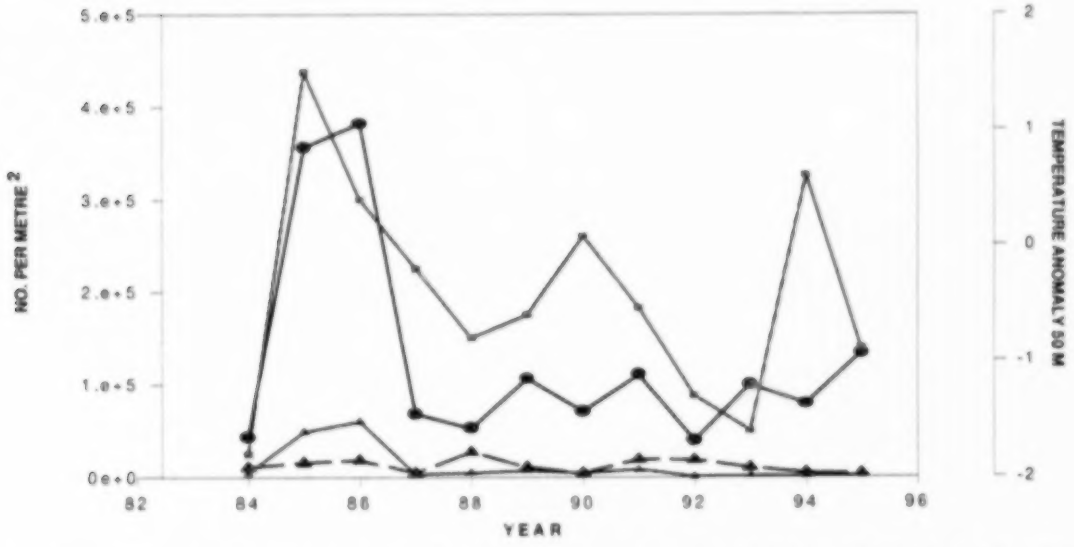

Fig. 7. Concentrations *Calanus* spp. per m^2 in Emerald Basin during the fall from 1984 to 1995 plus the temperature anomaly in the Basin at 50 m during June. The circles represent *C. finmarchicus*, the small triangles *C. glacialis*, the large triangles *C. hyperboreus* and the squares the temperature anomaly.

Conclusions

The plankton greenness index decreased in 1994 but it was still above the long term mean suggesting that levels of primary production may have also been above average. The abundances of most copepod species measured by the CPR were lower in 1994 than in 1993 and many of the species had levels lower than the long term mean. The two notable exceptions were *C. glacialis* on the SW Grand Banks and *Clausocalanus* on the Scotian Shelf and Georges Bank. *C. glacialis* is an Arctic species and their high numbers probably reflect the influence of the increased Arctic water on the Bank. *Clausocalanus* is an indicator species of slope water and its high concentrations on the Shelf and Georges Bank may have been due to increased Slope water influence in these areas. These data indicated that zooplankton concentrations in 1994 were only slightly lower than average on the Scotian Shelf and average on the SW Grand Banks. The Georges Bank data series is only four years long and therefore not long enough to calculate an accurate long term mean, however, since 1991 there has been a general decline in the level of copepod abundance on the Bank.

The Emerald Basin *Calanus finmarchicus* data indicated that since 1987 the population levels have been stable but much lower than in 1985 and 1986. There was a gradual increase in both euphausiid and fish population in the Basin between 1984 and 1994 followed by a steep decline in their population size in 1995. The causes for these declines are not known.

The fish larvae in the CPR samples were not identified and therefore we have no way of knowing if the increase in abundance since 1991 was due to one or more than one species, or if the same species contributed to the total number in different regions of the transect. There are some data on fish larvae from the BIONESS samples taken along the Halifax Line each year. These samples showed that the only species of fish larvae commonly caught are sand lance in the spring and summer and silver hake in the fall. In the fall of 1995 the numbers of silver hake larvae and juveniles were low compared to the pervious years.

References

Cochrane, N.A., D.D. Sameoto, and D.J. Belliveau. 1994. Temporal variability of euphausiid concentrations in a Nova Scotia shelf basin using a bottom-mounted acoustic Doppler current profiler. Mar. Ecol. Prog. Ser. 107: 55-66

Cochrane, N.A., D. Sameoto, A.W. Herman, and J. Neilson. 1991. Multiple-frequency acoustic backscattering and zooplankton aggregations in the inner Scotian Shelf basins. Can. J. Fish. Aquat. Sci. 48: 340-355

Herman, A.W., N.A. Cochrane, and D.D. Sameoto. 1993. Detection and abundance estimation of euphausiids using an optical plankton counter. Mar. Ecol. Prog. Ser. 94: 165-173

RD Instruments. 1990. Calculating absolute backscatter. Technical Bulletin ADCP-90-04. Issued Dec. 1990. RD Instruments, San Diego, CA

Sameoto, D., N. Cochrane, and A. Herman. 1993. Convergence of acoustic, optical, and net-catch estimates of euphausiid abundance: use of artificial light to reduce net avoidance. Can. J. Fish. Aquat. Sci. 50: 334-346

Sameoto, D. D. and A. W. Herman. 1990a. Life cycle and distribution of *Calanus finmarchicus* in deep basins on the Nova Scotia shelf and seasonal changes in *Calanus* spp. Mar. Ecol. Prog. Ser. 66: 225-237.

Sameoto, D.D., N. Cochrane, and A. Herman. 1990b. Use of multiple frequency acoustics and other methods in estimating copepod and euphausiid abundances. ICES theme session on measurement of zooplankter rates and biomass characteristics. Comm. Meet. int. Coun. Explor. Sea C.M.-ICES/L:81

Stanton, T.K., P.H. Wiebe, D. Chu, M.C. Benfield, L. Scanlon, L. Martin, and R.L. Eastwood. 1994. On acoustic estimates of zooplankton biomass. ICES J. mar. Sci. 51: 505-512

Waldron, D.E. 1988. Trophic behaviour of the silver hake (*Merluccius bilinearis*) population on the Scotian Shelf. Ph.D. thesis, Dalhousie University, Halifax, N.S.

Zhou, M., W. Nordhausen, and M. Huntley. 1994. ADCP measurements of the distribution and abundance of euphausiids near the Antarctic Paninsula in winter. Deep-Sea Research 41: 1425-1445